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DINOSEB

DRAFT

Health Advisory
Office of Drinking Water
U.S. Environmental Protection Agency

I. INTRODUCTION

The Health Advisory (HA) Program, sponsored by the Office of Drinking Water (ODW), provides information on the health effects, analytical methodology and treatment technology that would be useful in dealing with the contamination of drinking water. Health Advisories describe nonregulatory concentrations of drinking water contaminants at which adverse health effects would not be anticipated to occur over specific exposure durations. Health Advisories contain a margin of safety to protect sensitive members of the population.

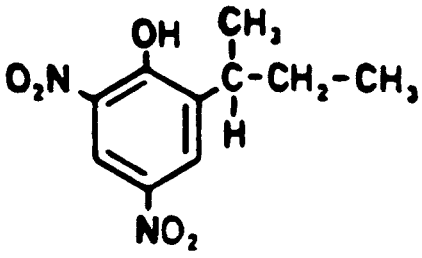
Health Advisories serve as informal technical guidance to assist Federal, State and local officials responsible for protecting public health when emergency spills or contamination situations occur. They are not to be construed as legally enforceable Federal standards. The HAs are subject to change as new information becomes available.

Health Advisories are developed for one-day, ten-day, longer-term (approximately 7 years, or 10% of an individual's lifetime) and lifetime exposures based on data describing noncarcinogenic end points of toxicity. Health Advisories do not quantitatively incorporate any potential carcinogenic risk from such exposure. For those substances that are known or probable human carcinogens, according to the Agency classification scheme (Group A or B), Lifetime HAs are not recommended. The chemical concentration values for Group A or B carcinogens are correlated with carcinogenic risk estimates by employing a cancer potency (unit risk) value together with assumptions for lifetime exposure and the consumption of drinking water. The cancer unit risk is usually derived from the linear multistage model with 95% upper confidence limits. This provides a low-dose estimate of cancer risk to humans that is considered unlikely to pose a carcinogenic risk in excess of the stated values. Excess cancer risk estimates may also be calculated using the One-hit, Weibull, Logit or Probit models. There is no current understanding of the biological mechanisms involved in cancer to suggest that any one of these models is able to predict risk more accurately than another. Because each model is based on differing assumptions, the estimates that are derived can differ by several orders of magnitude.

II. GENERAL INFORMATION AND PROPERTIES

CAS No. 88-85-7

Structural Formula



2-sec-butyl-4,6-dinitrophenol

Synonyms

- DNBP, dinitro, dinoseb (BSI, ISO, WSSA); dinosebe (France); Basanite (BASF Wyandotte); Caldon, Chemox General, Chemox PE, Chemsect DNBP, DN-289 (product discontinued), Dinitro, Dinitro-3, Dinitro General, Dynamite (Drexel Chemical); Elgetol 318, Gebutox, Hel-Fire (Helena); Kiloseb, Nitropone C, Premerge 3(Agway), Sinox General (FMC Corp.); Subitex, Unicrop DNBP, Vertac Dinitro Weed Killer 5, Vertac General Weed Killer, Vertac Selective Weed Killer (Meister, 1984).

Uses

- Dinoseb is used as a herbicide, desiccant and dormant fruit spray (Meister, 1984).

Properties (WSSA, 1983)

Chemical Formula	$C_{10}H_{12}N_2O_5$
Molecular Weight	240
Physical State (room temp.)	Dark amber crystals
Boiling Point	--
Melting Point	32°C
Density (°C)	1.2647 (45°C)
Vapor Pressure	(262°C) 100 mmHg
Specific Gravity	--
Water Solubility	0.05 g/100 mL
Log Octanol/Water Partition Coefficient	--
Taste Threshold	--
Odor Threshold	--
Conversion Factor	--

Occurrence

- Dinoseb has been found in 1 of 79 surface water samples analyzed and in 21 of 819 ground water samples (STORET, 1987). Samples were collected at 70 surface water locations and 814 ground water locations,

and dinoseb was found in California, Georgia and Ohio. The 85th percentile of all non-zero samples was 1 ug/L in surface water and 10 ug/L in ground water sources. The maximum concentration found in surface water was 1 ug/L and in ground water it was 100 ug/L.

- Dinoseb has been found in New York ground water; typical positives were 1 to 5 ppb (Cohen et al., 1986).

Environmental Fate

- Dinoseb was stable to hydrolysis at pH 5, 7, and 9 at 25°C over a period of 30 days (Dzialo, 1984).

- With natural sunlight on a California sandy loam soil, dinoseb had a half-life of 14 hours; with artificial light, it had a half-life of 30 hours, indicating that dinoseb is subject to photolytic degradation (Dinoseb Task Force, 1985a).

- In water with natural sunlight, dinoseb had a half-life of 14-18 days; with artificial light, it had a half-life of 42-58 days (Dinoseb Task Force, 1985b).

- With soil TLC plates, dinoseb was intermediate to very mobile in a silt loam, sand, sandy loam and silty clay loam (Dinoseb Task Force, 1985c).

- Soil adsorption studies gave a K_d of less than 5 for four soils: a silt loam, sand, sandy loam and silty clay loam, with organic matter content of 0.8 to 3% (Dinoseb Task Force, 1985d).

III. PHARMACOKINETICS

Absorption

- Following oral administration of dinoseb to rats (Bandal and Casida, 1972) and mice (Gibson and Rao, 1973) (specific means of administration not specified), approximately 25% of the administered dose appeared in the feces. However, following intraperitoneal (ip) administration in the mouse, approximately 40% appeared in the feces, thus suggesting to Gibson and Rao (1973) that dinoseb is initially completely absorbed following oral administration with subsequent secretion into the gut.

Distribution

- Following oral administration of dinoseb in the mouse (specific means of administration not specified), no appreciable amounts accumulated in the blood, liver or kidney (Gibson and Rao, 1973).

Metabolism

- While the metabolism of dinoseb has not been completely characterized, a number of metabolites have been identified including: 2-(2-butyric

acid)-4,6-diaminophenol, 2-(2-butyric acid)-4,6-dinitrophenol, 2-sec-butyl-4-nitro-6-aminophenol, 2-sec-butyl-4-acetamido-6-nitrophenol and 2-(3-butyric acid)-4,6-dinitrophenol (Ernst and Bar, 1964; Froslie and Karlog, 1970; Bandal and Casida, 1972).

Excretion

- In mice, dinoseb is excreted in both urine (20%) and feces (30%) following oral administration (specific means of administration not specified) (Gibson and Rao, 1973).

IV. HEALTH EFFECTS

Humans

Short-term Exposure

- While minimal data are available concerning human toxicity, at least one death has been attributed to an accidental exposure of a farm worker to sprayed dinoseb and dinitro-ortho-cresol (Heyndrickx et al., 1964).

Long-term Exposure

- No information was found in the available literature on the long-term health effects of dinoseb in humans.

Animals

Short-term Exposure

- In rats and mice, the acute oral LD_{50} of dinoseb ranges from 20 to 40 mg/kg (Bough et al., 1965).

Dermal/Ocular Effects

- In rats, the acute dermal toxicity of dinoseb ranges from 67 to 134 mg/kg (Noakes and Sanderson, 1969).

- No information was found in the available literature on the dermal or ocular effects of dinoseb in animals.

Long-term Exposure

- Hall et al. (1978) reported the results (abstract only) of a feeding study in male and female rats. Eight groups of rats, each group composed of 14 males and 14 females, were exposed to levels of 0, 50, 100, 150, 200, 300, 400 or 500 ppm of dinoseb (80% pure) in the diet for 153 days, respectively. Assuming that 1 ppm in the diet of rats is equivalent to 0.05 mg/kg/day (Lehman, 1959), these levels correspond to 0, 2.5, 5.0, 7.5, 10.0, 15.0, 20.0 and 25.0 mg/kg/day. Mortality was observed at 300 ppm (15 mg/kg/day) and above, and growth was depressed at all dose levels. The LOAEL for this study was identified as 50 ppm (2.5 mg/kg/day), the lowest dose tested.

- In a 6-month dietary study by Spencer et al. (1948), groups of male rats were exposed to dinoseb (99% pure) at levels of 0 (30 animals), 1.35, 2.7, 5.4 (20 animals) and 13.5 mg/kg/day (10 animals). Based on increased mortality at the highest dose and an increase in liver weight at intermediate doses, the NOAEL for dinoseb was identified as 2.7 mg/kg/day.

- In a study submitted to EPA in support of the registration of dinoseb (Hazleton, 1977), four groups of rats (60/sex/dose) were exposed to dinoseb (purity not specified) in their diets for periods up to two years at dose levels of 0, 1, 3 and 10 mg/kg/day, respectively. Although no evidence of dose-related changes in histopathology, hematology, blood chemistry or certain other parameters were observed, a dose-related decrease in mean thyroid weight was observed in all treated males. The LOAEL in this study was identified as 1 mg/kg/day.

Reproductive Effects

- In a reproduction study by Linder et al. (1982), four groups of ten male rats each were exposed to dinoseb (97% pure) in the diet at levels of 0, 3.8, 9.1 or 15.6 mg/kg/day over an 11-week period, respectively. In addition, a group of five animals was exposed to 22.2 mg/kg/day. The fertility index was reduced to 0 at 22.2 mg/kg and to 10% at 15.6 mg/kg/day; in neither case did the fertility index improve in 104 to 112 days following treatment. A variety of other effects were seen at levels of 9.1 mg/kg/day and higher, including decreased weight of the seminal vesicles, decreased sperm count and an increased incidence of abnormal sperm. The NOAEL for dinoseb in this study was 3.8 mg/kg/day based on a decrease in sperm count and other effects at higher levels.

- In a 2-generation rat reproduction study (Irvine, 1981), four groups of rats (25/sex/dose) were exposed to 0, 1, 3, and 10 mg/kg/day of dinoseb in the diet for 29 weeks. Although no reproductive effects were observed in this study per se, a decrease in pup body weight was observed at day 21 post-parturition for all dose levels. Thus, based on a compound-related depression in pup body weight at all dose levels, the LOAEL in this study was 1 mg/kg/day.

Developmental Effects

- Although dinoseb has been reported to be teratogenic (e.g., oligodactyly, imperforate anus, hydrocephalus, etc.) when administered to mice intraperitoneally (Gibson, 1973), it was not teratogenic when administered orally to mice (Gibson, 1973; Gibson and Rao, 1973) or rats (Spencer and Sing, 1982).

- Dinoseb (95% pure), administered to pregnant rats in the diet on days 6 through 15 of gestation, produced a marked reduction in fetal survival at doses of 9.2 mg/kg/day and above but not at doses of 6.9 mg/kg/day (NOAEL) and below (Spencer and Sing, 1982).

- Dinoseb (purity not specified) was without effect in a study in which pregnant mice were orally exposed to a single dose of 15 mg/kg/day (Chernoff and Kavlock, 1983).

- In a developmental toxicity study by Research and Consulting Company (1986), four groups of 16 Chinchilla rabbits were exposed to dinoseb (98% pure) by oral gavage at levels of 0, 1, 3 or 10 mg/kg/day from day 6 to 18 of gestation. At the highest dose level dinoseb produced a statistically significant increase in malformations and/or anomalies when compared to the controls, with external, internal (body cavities and cephalic viscera) and skeletal defects being observed in 11/16 litters examined. Neural tube defects, the major developmental toxic effect, included dyscrania associated with hydrocephaly, scoliosis, kyphosis, malformed or fused caudal and sacral vertebrae and encephalocele. The NOAEL for dinoseb in this study was identified as 3.0 mg/kg/day, based on the occurrence of neural tube defects at the highest dose level.

- In a study by the Dinoseb Task Force (1986), developmental toxicity was observed in Wistar/Han rats. Groups of 25 rats received dinoseb (purity 96.1%) by gavage at levels of 0, 1, 3 or 10 mg/kg/day from day 6 to 15 of gestation. Developmental toxicity was observed at the high dose as evidenced by a slight depression in fetal body weight, increased incidence of absence of skeletal ossification for a number of sites and an increase in the number of supernumerary ribs. Slight to moderate decreases in body weight gain and food consumption was observed in dams at the intermediate- and high-dose levels. Based on the occurrence of developmental effects at the highest dose level, a NOAEL of 3.0 mg/kg/day was identified.

Mutagenicity

- With the exception of an increase in DNA damage in bacteria (Waters, et al., 1982), dinoseb was not mutagenic in a number of organisms including Salmonella typhimurium, Escherichia coli, Saccharomyces cerevisiae, Drosophila melanogaster or Bacillus subtilis (Simmon et al., 1977; Waters et al., 1982; Moriyta et al., 1983).

Carcinogenicity

- No evidence of a carcinogenic response was observed in a 2-year chronic feeding study in which dinoseb was administered to rats at levels as high as 10 mg/kg/day (Hazleton, 1977).

V. QUANTIFICATION OF TOXICOLOGICAL EFFECTS

Health Advisories (HAs) are generally determined for one-day, ten-day, longer-term (approximately 7 years) and lifetime exposures if adequate data are available that identify a sensitive noncarcinogenic end point of toxicity. The HAs for noncarcinogenic toxicants are derived using the following formula:

$$HA = \frac{(NOAEL \text{ or } LOAEL) \times (BW)}{(UF) \times (\_\_\_ L/day)} = \_\_\_ mg/L \ (\_\_\_ ug/L)$$

ATTENTION

I. BACKGROUND

Over approximately the last 18 months, HEB/ODW has been developing a Health Advisory (HA) for the herbicide Dinoseb. Among other toxic endpoints, the Dinoseb HA notes that there is a positive rabbit oral teratology study with a NOAEL of 3 mg/kg/day- the basis of the proposed Ten-day HA value.

Subsequent to the latest HEB revision of the Dinoseb HA, a rabbit dermal teratology study and certain other studies became available. Both the rabbit dermal teratology study and the other studies are currently under Agency review. However, the rabbit dermal teratology is positive with a NOAEL of 1 mg/kg/day. In addition, the same toxic effect, neural tube defects, was observed in both the oral and dermal teratology studies.

II. ISSUE

While no final decision concerning Dinoseb can be made until all available data have undergone Agency review, the dermal teratology raises certain issues of concern to ODW. Specifically:

° Exposure to both the embryo and fetus is determined by the mother's exposure. Thus, in the case of a teratogen, woman of child bearing age are the group of principal interest.

° In the case of an adult - i.e. woman of child bearing age - the HA values are based on the consumption of 2 liters of water per day by a 70-kg adult.

° Considerably more water is used to bathe (roughly 100 L/day) than is ingested (2 L/day).

° Toxic amounts of Dinoseb can be readily absorbed dermally - i.e., the dermal NOAEL of 1 mg/kg/day is less than the oral NOAEL of 3 mg/kg/day.

° Since bathing and other practices involve dermal exposure to drinking water contaminants, it is at least possible that the dermal absorption of Dinoseb may result in significant exposure.

Until the issue of the dermal absorption of Dinoseb is resolved, ODW believes the following procedure should be used to allow for the positive dermal teratology study.

III. RESOLUTION OF ISSUE

A. Interim

Until such time as detailed data concerning the dermal absorption of Dinoseb are available, it is suggested that, on an interim basis, an HA value of 3.5 ug/L be used to evaluate all exposure situations (e.g. One-day, Ten-day etc.) where significant dermal exposure may be involved. This conclusion is based on the following analysis which suggests that a level of 3.5 ug Dinoseb/L will offer adequate protection against both the oral and dermal teratogenic potential of Dinoseb:

$$\text{Oral and dermal HA} = \frac{(1\ \text{mg/kg/day})(70\ \text{kg})}{(100)(102\ \text{L/day})} = 0.007\ \text{mg/L}\ (7\ \text{ug/L})$$

Where:

1 mg/kg/day = tentative NOAEL in rabbit dermal teratogenic study.

70 kg = assumed body weight of a woman of child bearing age.

100 = uncertainty factor, chosen in accordance with NAS/ODW guidelines for use with a NOAEL from an animal study.

102 L/day = possible volume of water from which all Dinoseb is either absorbed dermally (100 L) or ingested (2 L). While this value is possibly overly conservative, it provides an interim worst case until such time as Dinoseb dermal absorption studies (in progress) are available.

Normally, ODW uses a Relative Source Contribution (RSC) factor of 20% when the actual RSC is unknown. However, since it is at least possible that the RSC may be of some magnitude (due to dermal absorption), ODW has determined that it is appropriate to use an RSC of 50% in this case. Using an RSC of 50%, ODW recommends that an HA value of 3.5 ug/L (7.0 ug/L x 50%) not be exceeded.

B. Final

Any final conclusion must await the results of ongoing Dinoseb dermal absorption studies.

where:

NOAEL or LOAEL = No- or Lowest-Observed-Adverse-Effect-Level in mg/kg bw/day.

BW = assumed body weight of a child (10 kg) or an adult (70 kg).

UF = uncertainty factor (10, 100 or 1,000), in accordance with NAS/ODW guidelines.

___ L/day = assumed daily water consumption of a child (1 L/day) or an adult (2 L/day).

One-day Health Advisory

No information was found in the available literature that was suitable for determination of the One-day HA value. It is therefore recommended that the Ten-day HA value for a 10-kg child (0.3 mg/L, calculated below) be used as a conservative estimate of the One-day HA value.

Ten-day Health Advisory

The rabbit developmental toxicity study (Research and Consulting Co., 1986) in which dinoseb produced neural tube defects at doses greater than 3 mg/kg/day (NOAEL) was selected as the basis for determination of the Ten-day HA. While it is reasonable to base a Ten-day HA for the adult on a positive developmental toxicity study, there is some question as to whether it is appropriate to base the Ten-day HA for a 10-kg child on a such a study. However, since this study is of appropriate duration and since the fetus may be more sensitive than a 10-kg child, it was judged that, while it may be overly conservative, it is reasonable to base the Ten-day HA for a 10-kg child on such a study.

Using a NOAEL of 3.0 mg/kg/day, the Ten-day HA for a 10-kg child is calculated as follows:

$$\text{Ten-day HA} = \frac{(3.0 \text{ mg/kg/day})\ (10 \text{ kg})}{(100)\ (1 \text{ L/day})} = 0.3 \text{ mg/L} \quad (300 \text{ ug/L})$$

where:

3.0 mg/kg/day = NOAEL, based on the absence of teratogenic effects in rabbits.

10 kg = assumed body weight of a child.

100 = uncertainty factor; chosen in accordance with NAS/ODW guidelines for use with a NOAEL from an animal study.

1 L/day = assumed daily water consumption of a child.

Longer-term Health Advisory

The Hall et al. (1978) 153-day dietary dinoseb study in rats was originally selected to serve as the basis for determination of the Longer-term HA (decreased growth was observed at all exposure levels with a LOAEL of 2.5 mg/kg/day). Subsequently, however, a 2-generation reproduction study in rats (Irvine, 1981) was identified with a LOAEL of 1 mg/kg/day (based on a decrease in pup body weight at all dose levels). Since a reproduction study is of appropriate duration, the Irvine (1981) study has been selected to serve as the basis for determination of the Longer-term HA.

Using a LOAEL of 1 mg/kg/day, the Longer-term HA for a 10-kg child is calculated as follows:

$$\text{Longer-term HA} = \frac{(1.0 \text{ mg/kg/day})\ (10 \text{ kg})}{(1{,}000)\ (1 \text{ L/day})} = 0.010 \text{ mg/L } (10 \text{ ug/L})$$

where:

1.0 mg/kg/day = LOAEL, based on decreased pup body weight.

10 kg = assumed body weight of a child.

1,000 = uncertainty factor; chosen in accordance with NAS/ODW guidelines for use with a LOAEL from an animal study.

1 L/day = assumed daily water consumption of a child.

The Longer-term HA for a 70-kg adult is calculated as follows:

$$\text{Longer-term HA} = \frac{(1.0 \text{ mg/kg/day})\ (70 \text{ kg})}{(1{,}000)\ \ (2 \text{ L/day})} = 0.035 \text{ mg/L } (35 \text{ ug/L})$$

where:

1.0 mg/kg/day = LOAEL, based on decreased pup body weight.

70 kg = assumed body weight of an adult.

1,000 = uncertainty factor; chosen in accordance with NAS/ODW guidelines for use with a LOAEL from an animal study.

2 L/day = assumed daily water consumption of an adult.

Lifetime Health Advisory

The Lifetime HA represents that portion of an individual's total exposure that is attributed to drinking water and is considered protective of noncarcinogenic adverse health effects over a lifetime exposure. The Lifetime HA is derived in a three-step process. Step 1 determines the Reference Dose (RfD), formerly called the Acceptable Daily Intake (ADI). The RfD is an estimate of a daily exposure to the human population that is likely to be without appreciable risk of deleterious effects over a lifetime, and is derived from

the NOAEL (or LOAEL), identified from a chronic (or subchronic) study, divided by an uncertainty factor(s). From the RfD, a Drinking Water Equivalent Level (DWEL) can be determined (Step 2). A DWEL is a medium-specific (i.e., drinking water) lifetime exposure level, assuming 100% exposure from that medium, at which adverse, noncarcinogenic health effects would not be expected to occur. The DWEL is derived from the multiplication of the RfD by the assumed body weight of an adult and divided by the assumed daily water consumption of an adult. The Lifetime HA is determined in Step 3 by factoring in other sources of exposure, the relative source contribution (RSC). The RSC from drinking water is based on actual exposure data or, if data are not available, a value of 20% is assumed for synthetic organic chemicals and a value of 10% is assumed for inorganic chemicals. If the contaminant is classified as a Group A or B carcinogen, according to the Agency's classification scheme of carcinogenic potential (U.S. EPA, 1986), then caution should be exercised in assessing the risks associated with lifetime exposure to this chemical.

The 2-year dietary rat study by Hazelton (1977) was selected to serve as the basis for determination of the Lifetime HA. In this study, a compound-related decrease in mean thyroid weights was observed in all males (LOAEL = 1 mg/kg/day) treated with dinoseb (purity not specified).

Using a LOAEL of 1 mg/kg/day, the Lifetime HA for a 70 kg adult is calculated as follows:

Step 1: Determination of the Reference Dose (RfD)

$$RfD = \frac{(1 \text{ mg/kg/day})}{(1{,}000)} = 0.001 \text{ mg/kg/day}$$

where:

1 mg/kg/day = LOAEL, based on decreased thyroid weight in male rats exposed to dinoseb via the diet for up to two years.

1,000 = uncertainty factor; chosen in accordance with NAS/ODW guidelines for use with a LOAEL from an animal study.

Step 2: Determination of the Drinking Water Equivalent Level (DWEL)

$$DWEL = \frac{(0.001 \text{ mg/kg/day}) (70 \text{ kg})}{(2 \text{ L/day})} = 0.035 \text{ mg/L}$$

where:

0.001 mg/kg/day = RfD.

70 kg = assumed body weight of an adult.

2 L/day = assumed daily water consumption of an adult.

Step 3: Determination of the Lifetime Health Advisory

Lifetime HA = (0.035 mg/L) (20%) = 0.007 mg/L (7 ug/L)

where:

0.035 mg/L = DWEL.

20% = assumed relative source contribution from water.

Evaluation of Carcinogenic Potential

- No evidence of carcinogenicity was found in a 2-year dietary study in which dinoseb was administered to rats at levels as high as 10 mg/kg/day (Hazleton Labs, 1977).
- The International Agency for Research on Cancer has not evaluated the carcinogenic potential of dinoseb.
- Applying the criteria described in EPA's guidelines for assessment of carcinogenic risk (U.S. EPA, 1986), dinoseb is classified in Group D: not classified. This group is for agents with indadequate human and animal evidence of carcinogenicity.

VI. OTHER CRITERIA, GUIDANCE AND STANDARDS

- Tolerances have been established for dinoseb (40 CFR 180.281) at 0.1 ppm on a wide variety of agricultural commodities.
- The EPA RfD Workgroup approved a 0.001 mg/kg/day RfD for dinoseb. The EPA RfD Workgroup is an EPA wide group whose function is to ensure that consistent RfD values are used throughout the EPA.

VII. ANALYTICAL METHODS

- Analysis of dinoseb is by a gas chromatographic (GC) method applicable to the determination of certain chlorinated acid pesticides in water samples (U.S. EPA, 1985). In this method, approximately 1 liter of sample is acidified. The compounds are extracted with ethyl ether using a separatory funnel. The derivatives are hydrolyzed with potassium hydroxide, and extraneous organic material is removed by a solvent wash. After acidification, the acids are extracted and converted to their methyl esters using diazomethane as the derivatizing agent. Excess reagent is removed, and the esters are determined by electron capture GC. The method detection limit has been estimated at 0.07 ug/L for dinoseb.

VIII. TREATMENT TECHNOLOGIES

- The treatment technologies which will remove dinoseb from water include activated carbon and ion exchange. No data were found for the removal of dinoseb from drinking water by conventional treatment or by aeration. However, limited data suggest that aeration would not be effective in the removal of dinoseb from drinking water (ESE, 1984).

- Becker and Wilson (1978) reported on the treatment of a contaminated lake water with three activated carbon columns operated in series. The columns processed about 2 million gallons of lake water and achieved a 99.98 percent removal of dinoseb. Weber and Gould (1966) performed successful isotherm tests using Columbia LC carbon, which is coconut based, and reported the following Langmuirian equilibrium constants:

  Q = 444 mg dinoseb per g of carbon

  $1/b$ = 1.39 mg/L

  Though the Langmuir equation provides a good fit over a broad concentration range, greater adsorption would probably be achieved at lower concentrations (less than 100 ug/L) than predicted by using these constants.

- Weber (1972) has classified dinoseb as an acidic pesticide; and such compounds have been readily adsorbed in large amounts by ion exchange resins. Harris and Warren (1964) studied the adsorption of dinoseb from aqueous solution by anion exchanger (Amberlite® IRA-400) and a cation exchanger (Amberlite® IR-200). The anion exchanger adsorbed dinoseb to less than detectable limits in solution.

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